Memorandum

April 21, 1999

To: Gordon Olson, Chief of Research and Resource Protection, Denali National Park and Preserve

From: Carl Roland

Subject Recommended changes for the vegetation component of the Denali LTEM Program

Karen Oakley, Page Spencer, Dot Helm, and I met in Anchorage on March 2, 1999 to discuss the vegetation element of the long-term ecological monitoring program (LTEM) in Denali National Park and Preserve. The purpose of this meeting was to identify a clear and cohesive set of general objectives for continued vegetation monitoring in the Park, evaluate existing protocols in light of these objectives, and finally, to create an outline for the future of the program. Considerable progress was achieved in each of these areas. Our task now is to seek input from Park management and staff concerning the consensus reached at the meeting and the specifics of executing the proposed study objectives.

In summary, we make two recommendations. The first recommendation is to "scale-up" the monitoring program from its present narrow focus within the Rock Creek watershed to a sampling grid approach that is essentially Park-wide. The second recommendation is to broaden the inquiry to include issues other than climate-induced shifts in treeline and associated vegetation patterns, which was the concern driving the design of the original Rock Creek work. Specifically, we recommend that the new design be sufficiently robust that information pertinent to a range of management objectives, including issues that cannot be foreseen at this time, will be acquired.

In this memorandum, I begin by briefly describing the background work that lead to our meeting and discussions on March 2nd. I then address the modified program goals that we recommend. This is followed by a brief synopsis of the proposed future design changes to the vegetation monitoring protocol (at least those that have been developed so far). Finally, I provide a discussion of the changes (and continuity) that are envisioned for the current vegetation protocol.

Background

In the months prior to our meeting, a comprehensive review of current protocols and data was conducted. The results of these analyses were reported in two separate documents:

- Roland, C. 1999. Summary and analysis of vegetation data from Denali long term ecological monitoring program permanent plots, 1992-1998.

- Helm, Dot and C. Roland, 1999. Evaluation of existing protocols for Denali Long term ecological monitoring.

The analysis and evaluation process that resulted in these two documents provided the necessary groundwork for our discussions. The problems with the existing protocol that were identified in the review were of two kinds: (1) problems with sample allocation and statistical design, and (2) the lack of clearly stated objectives that mesh with Park management concerns.

Another important precursor to our discussion was the statistical review of the Denali LTEM project by West, Inc., that resulted in the following document:

- McDonald, Lyman et al 1998. Review of the Denali National Park and Preserve Long-Term Ecological Monitoring Program

The aforementioned review described the benefits of a systematic grid approach to sampling and the need for spatially-extensive sampling of Park and Preserve lands.

All of these documents are available on the Denali Long-term Ecological Monitoring Program web site
http://www.absc.usgs.gov/research/Denali/research.htm

Recommended Broad Goals of Long-Term Vegetation Monitoring at Denali

The statement of goals for a program that has the time depth (decades to centuries) and spatial extent (more than seven million acres) envisioned for the LTEM project in Denali must be organized in a hierarchical way, proceeding from the general to the specific, in order to facilitate a clear understanding of a complicated and multi-faceted project. In our meeting, we only addressed the higher-order, or general goals. The measurable objectives that will need to be accomplished in order to meet each of these larger goals will need to be clearly stated as the individual protocols are developed.

The purposes of the overall LTEM program listed in the *Strategic Plan* (1997) are to improve management decision-making using scientific information, to increase basic understanding of ecological dynamics of tundra and taiga ecosystems and to enhance national monitoring networks with sound data from an intact subarctic site. Clearly, the goals for the vegetation component must be framed within these broader program goals.

We organized the vegetation monitoring goals under three broad (and inter-related) categories of inquiry, which were:

(1) *Plant community composition*,
(2) *Plant community structure*, and
(3) *Ecosystem function*.

The *plant community composition* category includes all aspects of "who" makes up the vegetation of the park and in what proportions. Therefore, issues such as the species composition of major vegetation types, the distribution of rare and endemic plant species, concerns about exotic and invasive species, and changes in plant species distributions that occur as a result of human activities will be considered here.

The *plant community structure* category includes the extent and structure of the major vegetation types found in the Park. The central issues here include the relationship of vegetation structure to wildlife habitat variables, to natural disturbance regimes and plant succession, and to human activity and impacts (for example, increased fire frequency, trampling of sensitive vegetation, and impacts of ORV's that cause structural changes in the vegetation).

The *ecosystem function* category includes process, or rate-based, aspects of the vegetation including measures of productivity (such as biomass produced per unit area per unit time, or amount of browse per unit area) and phenology (the timing of green-up, senescence and reproductive events). Ecosystem function is directly influenced by humans through disturbance, atmospheric deposition, and global climate change. It is indirectly influenced by humans through changes in the structure and composition of the plant or wildlife populations in the Park.

The attributes of the vegetation in each of the above categories (composition, structure, and function) change along natural gradients of climate, topography, parent material, and successional stage within the Park. They are also subject to alteration, or disturbance, by human activities. As a result, it is important to document the existing natural variation and the important gradients underlying that variation, in order to understand the effects of humans, and other external stressors to the system. We recognized, however, that monitoring can identify correlations among parameters, but cannot necessarily demonstrate cause and effect relationships among them.

A major obstacle in outlining clear objectives for an ongoing *monitoring* program has been the absence of baseline, or "inventory" data for many important aspects that we need to assess changes in. For example, the absence of an adequate land-cover map, comprehensive fire history data, or even a reasonably complete species list, substantially hinder our capacity to assess change over time: change from *what*? Therefore, our approach will be to identify those aspects of Park vegetation that form a meaningful baseline data set (one that captures the essential elements of the vegetation resources of the Park), and then create a system for periodic reevaluation of these elements that will constitute the long- term monitoring program.

Below are sets of general objectives, in the form of questions, that we have identified, organized by the three goal categories outlined above.

Plant community composition

1. What is the species composition of the major vegetation types in the Park; how does this change in the different climate, topographic, substrate zones?

2. How does localized human use affect species composition of the vegetation (over time)? In other words, do impacted sites have a different species assemblage as compared to non-impacted sites?

3. What is the composition and distribution of the exotic plant flora currently found in the Park? Do we find any exotic species invading undisturbed, intact plant communities?

4. What are the different floristic provinces (or zones) of the Park, and where are the general boundaries among these provinces? Where are endemic and rare plant species concentrated on the landscape? What is the current degree of human impact in these zones of sensitive species concentration?

5. Can we develop a general model of plant species richness for the Park, or regions thereof?

Plant community structure

1. What are the dominant vegetation types within the Park, as represented by the sampling sites? How are these types characterized in terms of density, basal area, and percent cover, of the different strata of the vegetation?

2. What are the most important gradients (and limits) in the distribution and structure of these major vegetation types within the Park (for example, is a given type restricted to south of the Alaska range [climatic], to steeply sloping sites [topographic], or to sites on calcareous rock [substrate])?

3. What are types and (general) frequencies of natural disturbance associated with these vegetation types? For example, fires do not frequently affect sites supporting alpine tundra, but solifluction, frost-heaving, and various slope processes do.

4. How does the vegetation structure change over time following human and natural disturbance (i.e. what is the trajectory of succession in different vegetation types).

5. What is the current impact of localized human activities within each of these types (for example, a certain site in tundra may show trampling effects, or not, a forested site may have evidence of nearby campfires, or not, etc…)

6. What are the important wildlife habitat characteristics of the sampled vegetation types? Document evidence of wildlife species presence/abundance, amount of browsing, nesting birds etc…

7. Are there changes, over time, in the areal extent of different vegetation types on the landscape of the Park, or are there changes within these general types, in terms of density, basal area etc…of dominant taxa?

Ecosystem function

1. Can we quantify the productivity of the vegetation of the sites within the sampling grid (perhaps using remote sensing)? What is the inter-annual variation in productivity at the sampling sites? How does measured productivity relate to wildlife habitat variables?

2. When do the critical points in plant phenology occur (i.e. snow-melt, green-up, peak greenness, berry production, senescence)?. How does this vary across the sampling grid (along what gradients) and how does this phenology vary among years?

3. What is the relationship between the phenology and productivity measures mentioned above? In other words, can we make general assumptions about annual productivity based on relatively simple, general phenology data?

4. What is the annual variation in reproductive output by white spruce, the principal treeline species?

5. Can we develop a working, if very general, model of berry productivity for different regions of the Park? How does this relate to bear and other wildlife density models? How does berry productivity vary among years, in different landscape positions?

6. Is the chemistry of plant tissue, or anatomical norms for classes of plants changing over time in different regions of the park? Are these changes correlated with shifts in air quality parameters or other human influences?

7. Can we relate observed levels of productivity to models of nutrient cycling developed in other components of the LTEM? In other words: work on integrating physical and biological aspects of the program!

Clearly, the foregoing questions will be answered with different levels of precision depending on the degree of variability of the parameter being measured, and the relative expense of measuring it. Certainly, our data alone will be insufficient to completely answer all these questions. However, we feel that it is important to fully develop the list of issues we would like to see addressed, so that all potential sources of information can be marshaled towards the goal of adequately addressing all long term monitoring concerns. Information from short-term studies, anecdotal evidence, and field observations, among other sources, should be assembled under the umbrella of the LTEM program which should serve as a “clearinghouse” of information on what has been learned about the ecology of the Park over the years.

The primary constraints on the long term monitoring program are its spatial (Park-wide) and temporal (decades to centuries) scales. Obviously, given these rather extensive scales, the long-term monitoring program cannot be made into a tool that specifically targets particular short-term management issues. However, in the expanded format that we envision, it will provide useful information to help frame and guide management actions and to provide critical background data for the design of focused, short-term investigations.

Synopsis of general design changes to vegetation protocol to address the new goals and “scaling-up” of project

Following the suggestions of the statisticians last fall, we are investigating the use of a grid system to avoid selecting sites based on current vegetation or soils since these will change over time. The use of a grid also lends itself to GIS analysis and documenting long-term changes. Most large-scale inventory or monitoring programs that we are familiar with are based on grid systems for these reasons.

By using a grid, we are assured of reaching all areas of the Park. Initially, we thought a grid covering the entire Park would be too sparse to be meaningful. However, some preliminary analyses and assumptions suggest that a hierarchical design based on a grid system could be quite feasible and meaningful as well as being based on sound statistical design principles. The crux is selecting an appropriate grid size (one that is sufficiently-fine to encounter requisite variability within vegetation types within regions, while still being logistically achievable). At the broadest scale, all the points would only be sampled by remote satellite imagery although airborne methods would likely be used for specific parameters or areas. This grid would form the base from which all other sampling points would be selected.

In our proposed hierarchical design, a systematic subset of the overall set of grid points would be selected for actual field measurements. These 'extensive' plots would be where the vegetation composition and structure parameters would be measured, and monitored over time. The extensive plots could be concentrated in areas of management concern such as access corridors or other special areas so that adequate data are collected in these sites, while insuring that an adequate number of “control” sampling points are also included (those in unaffected areas). A smaller subset of points would be specifically selected for more 'intensive' measurements, which would include parameters related to ecosystem function, such as white spruce growth and reproduction. By using multiple-levels of sampling, we can sample extensively throughout the Park and intensively where a greater need exists.

A grid system such as this also provides a framework into which other components of the program can be integrated. Furthermore, vegetation crews would be able to collect some parameters, such as indicators of wildlife activity, in sites where it would not be justifiable to send out separate crews.

One system that we are investigating as a potential design template is the Forest Health Monitoring (FHM) system being implemented by the US Forest Service and other national and state agencies throughout the United States. The FHM protocol has already passed review by statisticians and has been used by several agencies. It has not yet been implemented in Alaska but will be very soon. The objectives of this program are to:

1. estimate the status, changes, and trends in selected indicators of forest ecosystem condition on a regional basis

2. identify associations between changes of trends in indicators of forest ecosystem condition and indicators of natural and human-caused stressors, (including changes in forest extent and distribution)

3. provide information on forest health

4. identify mechanisms of ecosystem structure and function through long-term monitoring of ecosystem processes at intensively monitoring sites representing major forest ecosystems

These objectives are close to some of those identified for the Denali LTEM program. One drawback is that the FHM scale is regional (27 to 40 km grid), and their vegetation composition measurements are not designed to detect species changes. However, by using a more intensive grid and adding to, or modifying, their design, we may be able to adapt the FHM protocol to our objectives. Further research needs to be done concerning the applicability of FHM to the needs of the Denali LTEM project. However, several states apparently are using the FHM design as a framework and have successfully adapted this sampling protocol to their specific needs.

Two real benefits of interfacing with the FHM network are that 1) it has been field-tested and pitfalls have already been identified and rectified with design modifications and 2) it is specifically designed for long-term monitoring. However, we will certainly have our own particular design considerations because of the logistical concerns inherent in working in remote Alaska and the spatial extent of our study area. We would greatly appreciate feedback from anyone who has specific knowledge of the FHM system.

Implications of these recommendations to the LTEM Program

The recommendations contained in this memorandum are made with the goal of maximizing the utility of the long-term monitoring program for park management and with the intent of formulating a clear, cohesive set of goals for the vegetation monitoring program. This represents a first step toward making several important changes in the long-term monitoring program as a whole. Input from management and others involved with the project will be critical to successful implementation of these goals. Clearly, the approach we have outlined will have significant implications for the rest of the LTEM program, as it was originally designed. These recommendations need to be reviewed by all program participants and their input received. We hope this memorandum (and the documents that preceded it) will provide a good starting point for those discussions.

Immediate implications for LTEM vegetation monitoring in Summer 1999

The proposed shift to a broader spatial scale for the vegetation monitoring program, and the changes involved in meeting the wider set of objectives outlined above both necessitate changes in the methods and protocols of the vegetation component of the long term monitoring program. Clearly, the significant departure from the present protocol envisioned by a Park-wide, sampling grid approach, will require concomitant changes in the current work being done in the Rock Creek watershed. However, this transition needs to be made in a considered and deliberate way so as to maximize the utility of the considerable work that has already been done in Rock Creek.

The evaluation of existing vegetation protocols shows that the phenology element and the berry productivity element of the current protocol have serious and unresolvable problems. Furthermore, they both require considerable field time (particularly the phenology study) and so are very high on the cost-benefit scale. Consequently, we recommend that the berry productivity and phenology monitoring elements, as currently designed, be discontinued immediately. We also recommend that the other work (dendrometer bands, cone and seed counts) should be continued in their current form until the scheduled ten-year remeasurement of the plots in 2002. At that time, an evaluation can be made as to what work should continue in the Rock Creek watershed.

Some of the current studies taking place in the Rock Creek plots may be augmented by the gathering of similar data in other areas of the Park. For instance, additional trees could be banded at sites on the south and west sides of the Park, which would amplify the usefulness of existing plots in the context of a spatially-extensive long-term monitoring project.

What's Next?

We offer these recommendations for consideration by yourself and the others involved in the Denali LTEM program. We hope that further discussions can occur soon, but recognize that actual decision making probably cannot, or should not, occur until the new LTEM Program Manager and Plant Ecologist are on board. However, in the meantime, discussions spurred by this memorandum should help move our thinking along closer to the point of defining our measurable objectives.

A study plan for the next two years of the USGS-Alaska Biological Science Center research effort related to the vegetation element of the Denali LTEM program is currently being prepared by Dr. Dot J. Helm, and will be ready for review by the park, the other

LTEM program investigators and by outside peer reviewers soon. The research effort will focus on exploring the grid approach, whether it is feasible and how it might actually work. In particular, the research will identify where the Forest Health Monitoring protocols do and do not meet the NPS objectives, and how the protocols would need to be modified.

One issue currently in discussion is how I should allocate my effort during the upcoming field season, given that work in Rock Creek will be somewhat reduced and the analysis and review of existing data is essentially complete. I am currently developing a recommendation that will take into account integration with the USGS research effort, and other work that would further the development of the LTEM vegetation protocol. One area where very considerable progress can be made *this year* is in additional plant inventory and voucher collections. All the preliminary work has been accomplished for this project, and valuable insights into regional vegetation and floristic patterns in the Park is gained through field work in this area.